SCIENTIFIC LETTER

Exercise does not cause an arm–leg blood pressure gradient in healthy children

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In normal subjects the systolic blood pressure (SBP) is lower in the arms than in the legs because of peripheral amplification of the pulse pressure.[1 2] The criteria for a successful repair of coarctation of the aorta include normal blood pressure (BP) and no resting arm–leg pressure gradient.[3] Some patients may develop an arm–leg pressure gradient only with exercise; thus, the diagnostic role of the exercise test after repair is important.[3] Recently, an exercise study of post-coarctation patients reported the development of a post-exercise arm–leg SBP gradient in healthy controls.[4] On the basis of their results, the authors questioned the role of measuring an exercise arm–leg pressure gradient to evaluate the success of a coarctation repair. We think that their results were spurious because of the methods used. The objective of our study was to determine whether healthy children develop an arm–leg SBP gradient with exercise.

METHODS

We recruited 12 healthy children between 10 and 17 years of age. The subjects were asked to rest on a recumbent cycle ergometer (Lode BV, Groningen, The Netherlands) for 5 min before we obtained resting measurements. Their ECGs were monitored before, during and after exercise. Appropriately sized BP cuffs (Baum Co Inc, Copiague, New York, USA) were placed on the right arm (RA) and thigh (RL), and Dinamap vital signs monitor automated BP cuffs (Critikon Inc, Tampa, Florida, USA) were placed on the left arm (LA) and thigh (LL). The auscultatory method with the mercury sphygmomanometers at appropriate heights was used to determine the SBP by the first Korotkoff sound and the diastolic blood pressure (DBP) by the fifth Korotkoff sound. BP was measured by auscultation in the RA and RL by two paediatric cardiologists. In our study, the start of all BP measurements was simultaneous. We recorded SBP and DBP for RA, RL, LA and LL; delay times, which were defined as the time it took from the signal to start BP measurement to when the BP values were obtained; and corresponding heart rates. Leg BP cuffs were removed after resting measurements were recorded.

The subjects exercised to volitional fatigue on the ergometer following a 20, 30 or 40 W every 3 min ramped protocol depending on the subjects' age. Immediately after exercise, BP cuffs were placed over the subjects' thighs and the manual BP cuffs were inflated to 20 mm Hg above the peak exercise RA SBP. We measured SBP and DBP for RA, RL, LA and LL; immediate post-exercise delay times; and heart rates. These same measurements were repeated 4 min after exercise.

RESULTS

Despite median delay times of 13.0 s for RA, 30.5 s for LA, 25.0 s for RL and 71.0 s for LL at rest, the median leg SBP was higher than the arm as predicted (right, 7.5 and left, 14.5 mm Hg, respectively). The immediate post-exercise median delay times were 40.0 s for RA, 47.5 s for LA, 51.0 s for RL and 80.5 s for LL, and the median arm SBP was higher than the leg on both the right and left sides (table 1). The time difference in the LA–LL (29.0 s) was consistently longer than in the RA–RL (13.0 s). The median SBP measurement for RL was significantly higher than that for LL (168.0 *v* 146.5 mm Hg, $p < 0.03$). Combining the results from both the right and the left sides, the longer the measurement delay time, the greater the difference in SBP between arm and leg ($r = 0.33$, $p < 0.05$).

The 4 min post-exercise median delay times were 16.0 s in the RA, 37.5 s in the LA, 26.5 s in the RL and 72.0 s in the LL. The median leg SBP was higher than the arm on both the right and left sides (1.0 mm Hg and 3.0 mm Hg, respectively), which was similar to the pre-exercise pattern.

DISCUSSION

Our study found that the auscultatory method was consistently faster than the Dinamap system and that the arm measurements were obtained faster than the leg measurements. Despite our attempts to obtain all of the measurements as rapidly as possible, some of the delay times were quite long. Under steady-state haemodynamic conditions, this did not matter, as the RA and LA SBPs were similar and, as expected, the leg SBPs were higher than the arm SBPs at rest and at 4 min after exercise. SBP falls rapidly once exercise is terminated,[5] with a 40–50 mm Hg drop within 4 min of the cessation of exercise. Any delay in obtaining the BP is, therefore, not representative of the peak SBP or, if two limbs are being compared, any SBP difference between them. Thus, in the immediate post-exercise period, the delay in obtaining the leg BP with the Dinamap system would result in a spurious BP gradient between the arm and the leg. "Arm–leg BP gradient" implies that simultaneous BP measurements were taken. Clearly, in the immediate post-exercise period, when the haemodynamics are rapidly changing, the delay in obtaining the leg BP would account for the lower measurement obtained, even in normal people.

Very little information was given about the technique used in the Swan *et al*[4] study; the delay in taking the arm and leg BPs from the cessation of exercise was not stated. To minimise any delays, we exercised our subjects on a recumbent cycle ergometer instead of a treadmill. Thus, the method used by Swan *et al*[4] incorporated at least two major sources of delay in obtaining the BP.

There are difficulties with the auscultatory method of measuring BP,[6] and the accuracy of the Dinamap in measuring BP and its use in the paediatric population have been controversial. An intravascular study of post-coarctation patients found that the measurement of resting and exercise-induced SBP gradients with a Dinamap was inaccurate.[7]

We have shown that attention to detail is essential when measuring BP during exercise studies, especially immediately after exercise. Arm and leg BP should be measured within 10–15 s of each other and, preferably, the leg BP should be measured first. Healthy children and, we assume, young adults do not have a physiological arm–leg SBP gradient at rest or with exercise. Dinamap vital signs monitors should not be used to assess BP gradients in rapidly changing haemodynamic states.

Abbreviations: BP, blood pressure; DBP, diastolic blood pressure; LA, left arm; LL, left thigh; RA, right arm; RL, right thigh; SBP, systolic blood pressure

Table 1 Immediate post-exercise measurements and gradients

	Right arm	Right thigh	Left arm	Left thigh
Delay time (s)	40.0 (33–55)	51.0 (40–160)	47.5 (38–69)	80.5 (61–227)
Heart rate (beats/min)	125.0 (90–160)	118.5 (85–152)	121.5 (82–155)	113.0 (100–141)
Systolic pressure (mm Hg)	172.0 (142–199)	168.0 (134–204)*	173.5 (127–209)	146.5 (121–167)*
Arm–leg systolic gradient (mm Hg)	3.0 (−20–>13)		19.0 (−10–>65)	
Time difference (s)	13.0 (2–105)		29.0 (16–168)	

Median values (range) are reported.
*p<0.03.

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IMAGES IN CARDIOLOGY

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Cardiac arrest after occlusion of anomalous origin of left main artery

A 40-year-old woman presented at the emergency room with typical angina of one hour's duration. The ECG showed ST segment elevation in the precordial and lateral leads (panel A). Ten minutes later the patient went into primary ventricular fibrillation which was successfully defibrillated, but she developed arterial hypotension. The patient underwent coronary angioplasty which showed thrombotic occlusion of the distal left main artery (TIMI 1 flow) arising from the right coronary artery (panel B). Successful angioplasty and stent placement were undertaken in the anomalous left main artery (panel C). The patient remained in Killip class I during hospitalisation and was discharged five days later in good clinical condition.

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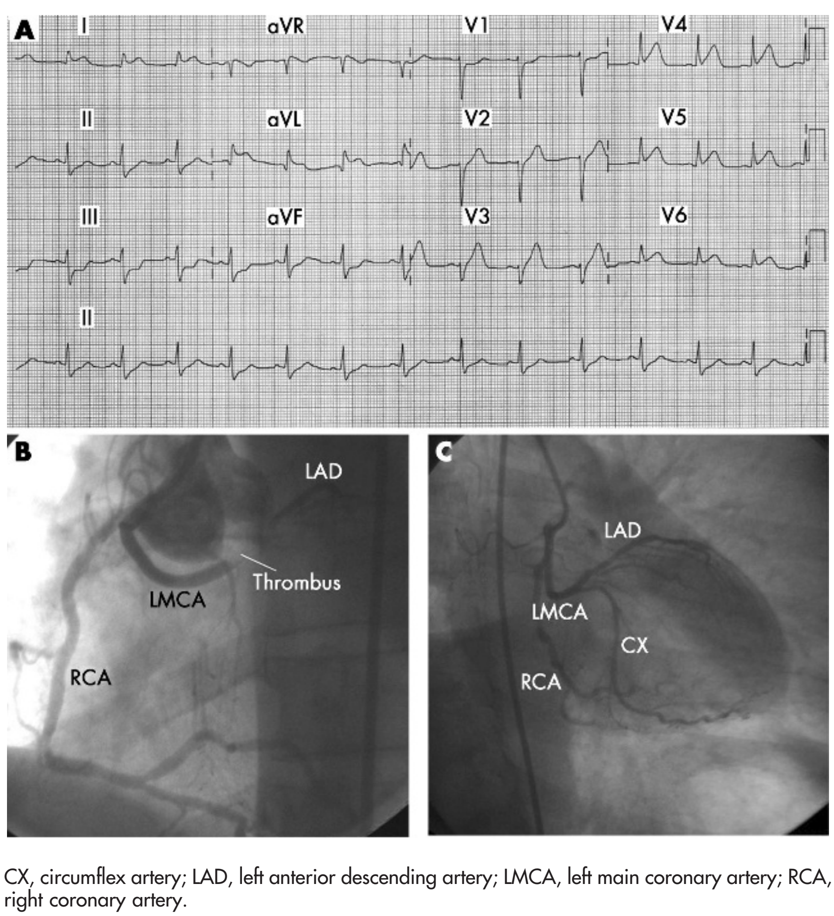

CX, circumflex artery; LAD, left anterior descending artery; LMCA, left main coronary artery; RCA, right coronary artery.